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14. ABSTRACT
A computationally robust, user friendly, and physically accurate modeling system has been implemented to provide short-term forecast capabilities in support of real-time Naval operations. MODAS nowcast provides initial and boundary condition for NRLPOM, a version of the Princeton ocean model. NRLPOM includes tidal forcings and has the capability to be coupled with other large-scale models and nesting between domains of different grid resolutions. The MODAS-NRLPOM prediction system has been evaluated in several areas and configurations.

15. SUBJECT TERMS
Relocatable ocean model - real-time applications
Model evaluation - model-model and model-data comparison

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Advanced Modeling System for the Gulf of Mexico: Evaluation and Validation of the NRLPOM Relocatable Model

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LONG-TERM GOALS

The long-term objectives are to implement a user-friendly, computationally robust, and physically accurate modeling system to provide short-term forecast capabilities in support of real-time naval operations.

OBJECTIVES

MODAS-NRLPOM is a scalable, portable, and rapidly relocatable system for nowcast and short term (2-day) forecast simulations. There are two major components: 1) the Modular Ocean Data Assimilation System (MODAS) to generate a nowcast field to initialize 2) the Naval Research Laboratory Princeton Ocean Model (NRLPOM).

The primary objective is to evaluate the operational system. There is a fundamental difference in assessing a predictive system in a research and in an operational mode. A research predictive system is designed, calibrated, and evaluated to encompass the dominant dynamics of a given region. The goal is to provide the *most accurate* representation of the dynamical features of a *specific* area. A predictive system, which supports operational applications, must be rapidly relocatable anywhere in the ocean (oil-spill and naval exercises are the most relevant applications), and easily reconfigured. The principal goal is to provide *good* representations *everywhere* with the available data (i.e., in spite of the lack of observations). In this respect, different metrics and criteria should define the evaluation of the two modeling approaches.

APPROACH

Our work has focused on the evaluation of the physical accuracy of 1) MODAS nowcast and 2) NRLPOM forecast. The working hypothesis is that MODAS field is accurate enough to allow a dynamical model to spin up the correct physics in coastal and littoral regions. More specifically, we have performed real-time experiments and hindcast simulations in several areas and configurations, ranging from basin-scale to inlets, from deep to coastal domains.

WORK COMPLETED

We have delivered to NRL the latest version of NRLPOM which includes new features implemented to increase the computer robustness and physical accuracy, such as: 1) initialization procedures, 2) tidal forcing, and 3) open boundary conditions (OBC).

RESULTS

1) Initialization is based on cold/warm/diagnostic (and combination) procedures. The default is a cold start from MODAS with wind at -24/48 hrs. to build the mixed layer. The procedure is numerically robust, but less accurate since everyday starts from scratch. Moreover, the variability of coastal areas may be characterized by highly energetic, but short time-scale, features which make it difficult to assimilate into the MODAS nowcast knowledge of the ocean's past state. As Figure 1 illustrates, MODAS fields may tend to relax toward climatology, in the case of persistent cloud coverage. Therefore, NRLPOM includes an option (henceforth referred as to the long-run simulations) in which the forecast is from a warn restart from the previous day nowcast (not POM's typical restart procedure).

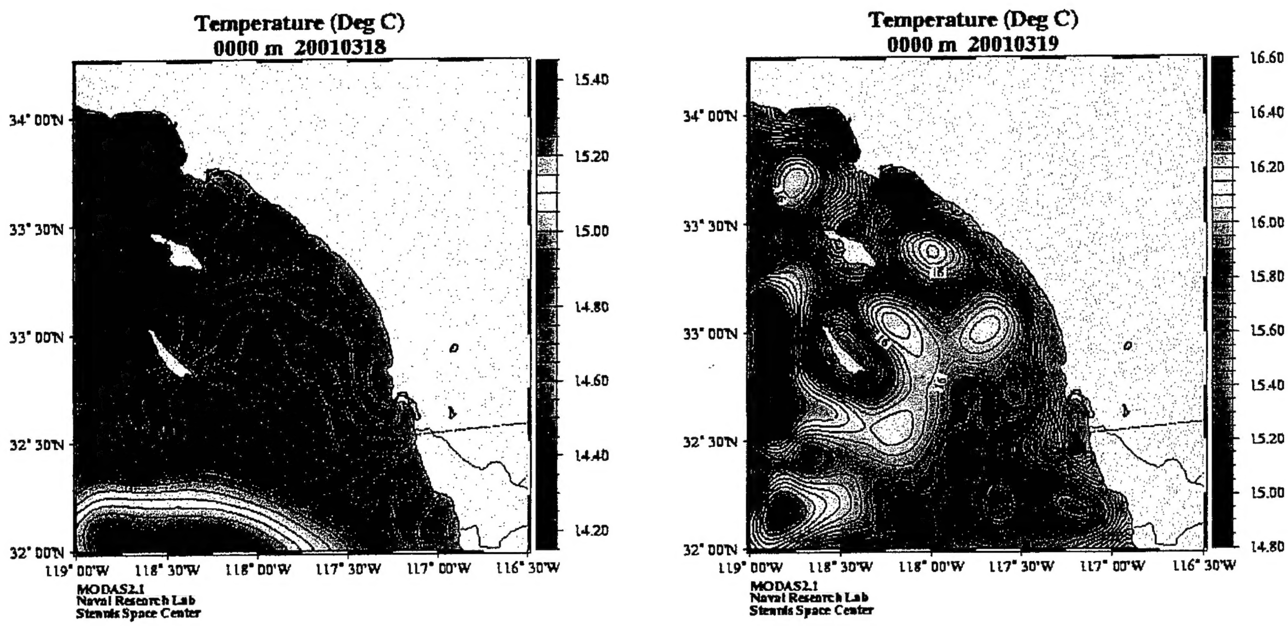

Fig. 1.: MODAS nowcast field from two consecutive days a) persistent cloud coverage, b) clear day. Due to the coastal environment, no altimetry data are assimilated.

2) Open Boundary Conditions. While MODAS estimates the baroclinic component under the geostrophic assumption, the barotropic velocities are often inadequate, primarily where it is not possible to estimate the dynamic height (i.e., transport) and make use of altimetry data. To partially remove the problem, NRLPOM has the capability of substituting MODAS barotropic field with the barotropic, non-tidal flow from other existing circulation models (Fig. 2). This approach offers three major advantages:

- The barotropic field can be estimated from a variety of models including layer, z, σ, and hybrid-levels formulations.
- Only horizontal (no vertical) interpolation is required.
- Due to the short-term applications, it is not necessary to update the non-tidal reference values as the computations proceed (i.e., only one exchange of information between the models) (Fig. 3).

The major limitations are that the algorithm does not allow tidal-to-tidal model coupling, the procedure cannot be applied for long-term applications, and a severe mismatch may occur between the barotropic and baroclinic boundary velocities.

The Monterey Bay Real-Time Simulations

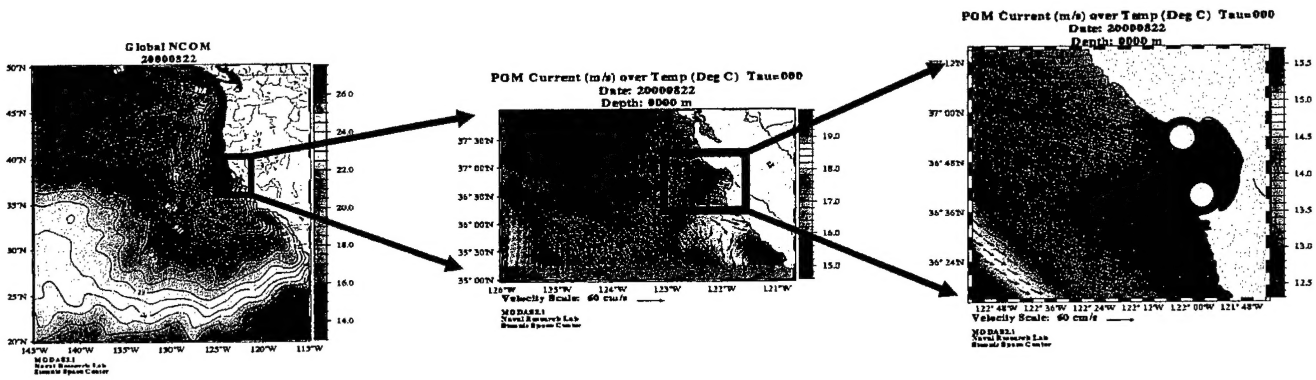

Fig. 2a. Example of model coupling: Global 1/4 ° NCOM (25 km resolution) provides transport values at the boundary of NRLPOM regional model for the California Current which provides transport values for the NRLPOM local model with tidal forcing.

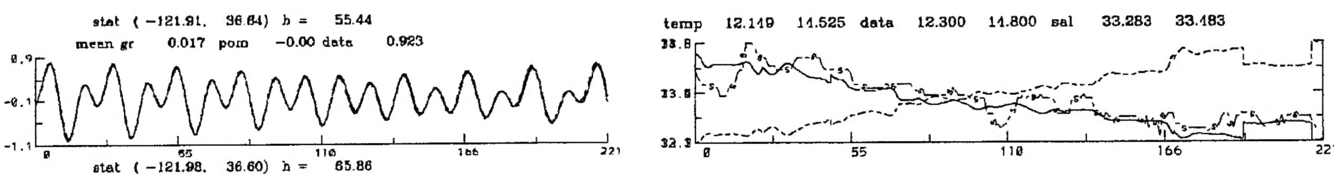

Fig. 2b: Model-data comparison with tide gauge and buoy measurements in the Monterey Bay area. The model solutions are from long-run forecasting simulations as previously described.

3) Tidal forcing. Flather's BC requires reference values for both elevation (SSE) and velocity. While SSE can be estimated from models of the tidal constituents, it is more difficult to acquire the velocity values. Since there exists a clamped tidal solution, the algorithm unfolds as follows:

- SSE from the Grenoble Model is updated each baroclinic time step with zero reference tide velocities.
- At the boundaries, SSE is nudged to Grenoble solution: with a typical 3-6 hrs. nudging time scale (the value was determined through numerical tests to yield adequate tidal amplitude of the interior points).

Figure 3 illustrates some model-data comparison in several coastal regions. The tide gauge data are from the NOAA Center for Operational Oceanographic Products and Services tide gauge stations, extracted from the web page: http://www.co-ops.nos.noaa.gov/.

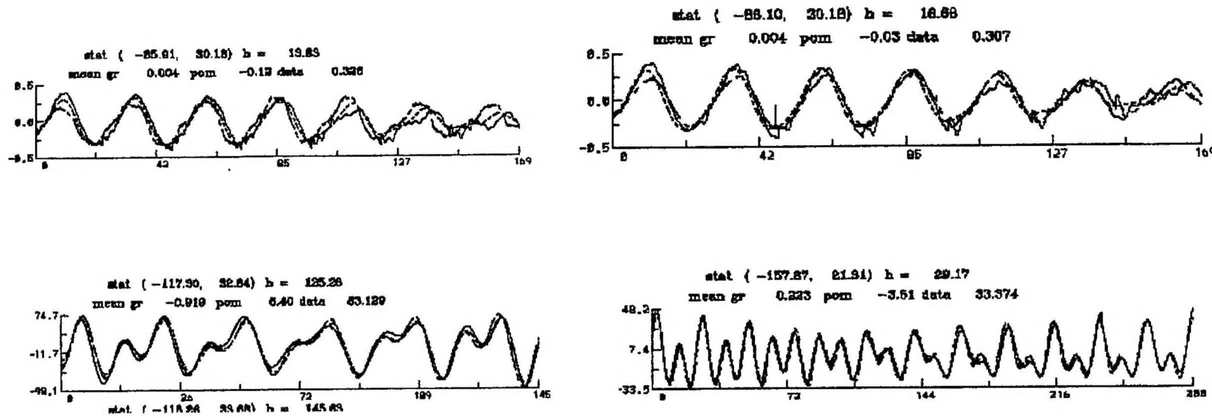

Fig. 3a: Comparison between the forecasted tidal amplitude and gauge data from several model simulations. A) Panama City, B) Pensacola, C) LaJolla, and D) Pearl Harbor.

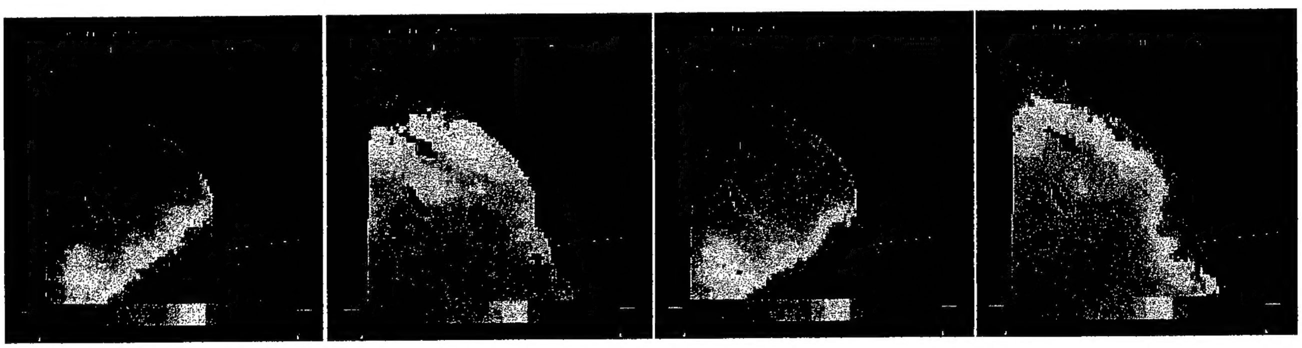

Fig. 3b: The residual tidal circulation on the Southern California, Santa Barbara Channel region. Snapshots are every 6-hour interval.

IMPACT/APPLICATIONS

An earlier version of MODAS-NRLPOM is routinely applied at NAVO in several areas and configurations, ranging from basin-scale to inlets, from deep to coastal domains. MODAS-NRLPOM has been applied in support of the real-time Naval exercise Kernel Biltz 01 off the San Diego coast. The model is currently applied at NAVO in providing currents around the shallow Ehime Maru recovery site (specifically to assist in forecasting where oil and other items would drift).

TRANSITION

Transition to NAVO is in progress.

RELATED PROJECTS

This research provides a test bed for the development and evaluation the Distributed Environmental Forecast System (DMEFS) framework. The research is the result of an active collaboration with NRL CODE-7320. Related projects include:

- 6.4 SPAWAR On-Scene Tactical Ocean Forecast Capability (D. Fox)
- Relocatable Models (R. Preller)

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